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DIODE ARRAY SIDE-PUMPING OF A LASER SYSTEM

Field of the Invention

The present invention relates to diode pumped laser systems.

Background of the Invention

Diode pumped solid-state crystal lasers are becoming increasingly popular due to their compact nature and high output power characteristics.

However, for optical signal processing applications it is desirable to utilise pumped waveguides to produce a laser output rather than solid-state crystal lasers, which are more difficult to incorporate into e.g. optical integrated circuits.

Suitable waveguides include e.g. doped cores of optical fibres or doped planar waveguide structures.

Such waveguides, i.e. those which are capable of producing a laser output upon pumping with a pump energy, presently require an efficient coupling of the pump energy light signal into e.g. the doped core of the optical fibre via the fibre cladding.

To minimise coupling losses various coupling techniques have been suggested, however, it is a common feature that they do require additional components/ structures which need to be integrated into e.g. the optical integrated circuit, thereby resulting in more complex and less compact designs.

Furthermore, typically individual sources of the pump energy light signals are required for each waveguide to be pumped, the sources being individually coupled to the respective waveguides.

Summary of the Invention

In accordance with the present invention, there is provided a laser system comprising: at least one array of closely spaced diodes arranged to emit radiant pump energy, and a plurality of waveguides spaced adjacent the array, each waveguide being arranged to lase upon exposure to the radiant pump energy emitted from the diodes.

A single diode array is thus utilised as a single source for the pumping of multiple waveguides at one time, without a requirement for individual coupling means.

The waveguides may be arranged to lase at different frequencies. This can e.g. be utilised for provision of multiplexed optical signals.

The system can further include a coupler for coupling laser outputs of individual waveguides to form a combined laser output.

The system may further comprise reflection means spaced closely adjacent the waveguides and the array for reflecting the radiant pump energy emitted from the array back onto the waveguides.

The plurality of waveguides can comprise a series of optical fibres or of planar waveguides.

The waveguides may form a multi-mode interference device.

The waveguides can be formed as part of a multimode waveguide structure which can be interconnected to a single mode waveguide.

Brief Description of the Drawings

Notwithstanding any other forms which may fall within the scope of the present invention, preferred forms of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Fig. 1 illustrated a first example embodiment of the present invention;

Fig. 2 illustrates a second example embodiment of the present invention;

Fig. 3 illustrates a third example embodiment;

Fig. 4 illustrates a fourth example embodiment;

Fig. 5 illustrates utilisation of the principle of the present invention in a multi-mode interference device; and

Fig. 6 illustrates a further embodiment of the present invention

Description of Preferred and Other Embodiments

In Fig. 1, there is illustrated a first example embodiment 1 of the present invention. In this embodiment, a series or bundle waveguides in the form of distributed feedback (DFB) fibre lasers 2, which can include tuned Bragg grating structures to provide for particular frequency characteristics, are pumped by a diode bar 3. In the example, 32 DFB lasers are assumed to be provided. Of course, alternative arrangements are possible for example, the fibres could be more spaced apart and form a single layer on the diode bar. Obviously, many different slacking arrangements are possible. The diode bar 3 acts as a high intensity pump which causes the DFB lasers to lase. The fibres are attached together by a 32 to 1 splitter 6 so as to provide output 7 having multiple combined frequency channels.

The principles of Fig. 1 can be extended to other waveguide systems. For example, in Fig. 2, there is illustrated a waveguide system wherein a diode bar 10 is placed upon a waveguide 11 on which a series of DFB lasers 12 are formed in the core. The diode bar 10 is utilised to pump the DFB lasers 12 to provide for outputs 13.

Other arrangements are possible as illustrated in Fig. 3 wherein a waveguide 20 is provided on a substrate 21 and a diode bar 22 is provided for pumping the waveguide 20. The diode bar 22 is inclined with respect to the substrate 21 so that pumping wavelength energy is reflected by the substrate 21 and in turn by a reflector 24 so as to provide for enhanced operational characteristics. The pumping causes the waveguide 20 to laze so as to produce output 25.

In Fig. 4, there is illustrated an alternative arrangement where the diode bar 30 is placed at one end of the substrate 31 which includes a series of DFB waveguides 32 placed therein. The diode bar 30 is utilised to cause the DFB lasers to laze 32 so as to produce output 33.

The arrangements of Fig. 1 - 4 provide for an inexpensive form of arrangement of diode pumping of

multiple waveguides simultaneously. This has significant advantage when constructing laser devices or other large area pumping of active waveguides. An example of its application is in the field of multi-mode interference devices. These devices can be, as illustrated in Fig. 5, formed on a waveguide 40 and include a series of active waveguides 41 between two couplers 42, 43. The diode bar 44 can be placed over the active portions so as to provide for large area pumping of the active waveguide portions 41 and therefore provide for different output couplings from input 46 to output 47 in accordance with requirements.

Turning now to Fig. 6, there is illustrated a further embodiment where a large power coupling is required for high power applications. A diode bar 50 is utilised to pump a large area multi-mode waveguide 51 which in turn is tapered into a single mode waveguide 52 so as to provide for high output power 53 pump wavelength which in turn can be utilised to pump other devices.

It would be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

In the claims that follow and in the summary of the invention, except where the context requires otherwise due to express language or necessary implication, the word "comprising" is used in the sense of "including", i.e. the features specified may be associated with further features in various embodiments of the invention.